Chapter-2: Review of Literature
Jojoba is a drought-tolerant recurrent shrub (Borlaug et al., 2002). Its seeds contain about 50% oil (liquid wax) which has been proved as a good substitute to the sperm whole oil. Jojoba plantations are documented whale oil. Jojoba plantations are well-known via seeds seedlings deep-rooted cuttings or plantlets from tissue culture. Generally, the male plants outnumber the female plants when raised from seeds. Being dioeciously a seeded plantations of jojoba has genetic heterogeneity and low average yields (Benzioni, 1997). Vegetative circulation enables the establishment of plantations with the desired quantity of male to female plants from preselected superior clones (Benzioni, 1997).

It also creates consistency, high yields, early behavior and condensed cost of instructive and harvesting operations (Palzkill, 1988). Attempts have been made to broadcast jojoba vegetative from side to side air layering (Reddy, 2003; Bashir et al., 2009), grafting. Stem cuttings and tissue culture (Bashir et al., 2009). Although jojoba is a difficult to root plant yet proliferation through cuttings is the most commonly used androgynous method with limited success (Feldman, 1982).

Victorious rooting of jojoba cuttings can be achieved by the use of different auxins. The rootings rates of cuttings treated with IBA, NAA and IAA teach (at 100 mg/l) were 82, 80 and 76%. Respectively and the rooting time for cuttings ranged from 125 to 261 days (Zhou, 2002). The rooting ratio of semi hardwood cuttings was increased by IBA @1000B mg/l and the rooting ratio of youthful individual was higher than the mature ones (Cao and Gao, 2003). Clonal differences for rooting ability of semi hardwood cuttings treated with 2000 mg/l IBA intermittent mist were evident among 12 clones of jojoba (Lee and Palzkill, 1984).

Marked differences in the rooting from different genotypes of jojoba were condensed by IBA+WOUND (Howard et al., 1984). Thomson, 1982, reported 30 to 70% rooting in fatal cuttings treated with 4000 mg/l IBA using irregular mist in a partially shaded green house (Brown and Campbell, 1985). Feldman et al., 1983, rooted the cuttings of 20 different male jojoba plants by treating with 4000 mg/l IBA for 15 seconds by treating with 4000 mg/l IBA for 8 seconds every 4 minutes,
creating an atmosphere of 100% damp at the leaf surface of jojoba stem cuttings. Without saturating the rooting medium had contributed to a high degree of rooting.

Benzioni, 1997, record rooting of jojoba cuttings within substrate temperature of 30 °C and mist functional for 10 seconds every 8 – 10 minutes. Bashir et al., 2001, recorded 61% rooting in semi hardwood cuttings of jojoba just dipped in 4000 mg/l IBA solution under partially shaded polyethylene sheet tunnel having 90 to 95% humidity with mean temperature of 15 - 30°C. The cuttings did not react to 500 mg/l IBA even increasing the dipping time. Singh et al., 2003, conducted study to determine the effect of IBA at (500,1000,2500,3000,4000, 5000,6000,8000,10,000 and 15000 mg/l respectively) with boric acid (at 31 mg/l) on adventitious rooting of jojoba stem cuttings. The quick dip (20-30 seconds) method of IBA (15000 mg/l) with boric acid effectively caused rhizogenesis in young sprout of 1to 2 year old branch.

Since jojoba was produced in Pakistan during mid 1980’s. It could not prosper due to problems in propagation to get true –to-type plants. Development of superior genotypes via rooted cuttings will help in multiplication of superior genotypes via deep-rooted cuttings will help in multiplication of the future variety of jojoba that might solve the male and female plant –ratio problems in the fields per plant compared to the average yield from seedlings. The aim of the present study was to develop a cheaper and accessible technique for rooting the jojoba cuttings through using a suitable auxin with its optimum attentiveness. Ultimately to multiply true –to-type uniforms. Desirable selections to establish jojoba plantations in Pakistan.

The seeds of jojoba produce a fluid wax can be used as replacement for sperm whale oil. The wax is of huge commercial value. Particularly as a high – pressure lubricant (Yermanos, 1979). Jojoba oil is also used in cosmetic industry, hair care products, during pharmaceuticals and also as low calories edible oil (Naqvi and Ting, 1990).The vegetative propagation of this plant by usual horticultural methods is difficult. Rooting of cuttings besides being slow, requires considerable controlled greenhouse facilities (Dror, 1981). Furthermore, there are certain other horticultural limitations since from a particular elite individual only a few cuttings
can be achieved only if the cuttings can be obtained and the rooting can be achieved only if the cuttings of newly toughened incurable shoots are taken during a meticulous period of the year (Chaturvedi and Sharma, 1989).

Plant tissue culture technology has a potential to overcome these problems. Micro propagation is one of the most worldwide methods of biotechnology, allows sufficient and rapid clonal propagation of many economically important crops. However, the low percent survival of in vitro plantlets during the ex vitro acclimatization’s stage is a real problem. Efforts have been intensified in overcoming this problem by encapsulating somatic embryos and shoot bud explants in different matrices and alternating to grow these synthetic seeds (synseeds) on different substrata (Pattnaik and Chand, 2000).

Successful cases of synthetic seeds production and plantlets regeneration have been reported for cereals vegetative, fruits, ornaments, aromatic grass and conifers.

However, in most cases somatic embryos were used in the encapsulation process. Few journalists described the encapsulation of vegetative propagules such as axillary buds or shoot tips which could be used for mass clonal propagation as well as in long –term conservation of germplasm. The current study described the encapsulation of shoot tips and axillary buds obtained from in vitro shoot culture of jojoba in calcium alginate gel, and the victorious development of plantlets from these capsules on various planting media (Hassan, 2003). Jojoba is a desert shrub which tolerates brackish and alkyls soils and drought. The seeds contain a characteristics liquid wax of economic importance in industry (machine lubricant) and medicine (e.g. cosmetics and anti cancer compounds (Mills et al., 2004).

A major problem in seeds manufacture is that jojoba is a dioecious plant where its sex is not easily strong-minded prior to flowering (3 – 4 years from cultivation). Plant regeneration via tissue culture is an important tool in mass proliferation, mutant selection and genetic transformation. Tissue culture techniques have been applied only to a limited extent in jojoba.
Micropropagation of jojoba offers a promising method for mass production of superior pathogen–free clones for commercial plantations (Mills et al., 1997). In the protocol, jojoba sealed tubes were recommended in all four stages of in vitro propagation. However, jojoba plantlets produced in tightly closed growth vessels exhibited anatomical morphological and physiological abnormality (Apostolo and Llorente, 2000) due to hyperhydricity (Ziv, 1991).

The advantages of using asexual proliferation in commercial jojoba plantations are that they provide uniform and expected plant growth in addition to give way. Furthermore, jojoba is dioecious and cannot be sexed until flowers appear (usually 2-4 years as of seed). Clonal proliferation of elite individuals of recognized sexuality is necessary to ensure that the plants in profitable plots determination be productive (Chaturvedi and Sharma, 1989). Vegetative propagation can be achieved by rooting semi hardwood cuttings. But the maximum number of possible propagules is limited by plant size and time of planting. Jojoba plants from tissue culture grow more energetically than both seedlings and rooted cuttings, and are considerably larger after the first year of growth (Rugini et al., 1943) thus micropropagation offers opportunities for the production of thousands of elite plants from the chosen stock plant.

Consequently, several investigations have attempted clonal proliferation of jojoba tree (Mills et al., 2009; Tyagi and Prakash, 2004). Most of this information deals with juvenile material or material of not mentioned age. Most reports lack vital information such as the rate of multiplication in recurring subcultures. However, the present study reports a highly reproducible and recurrent method of clonally propagation of a 5-year-old jojoba tree through axillary shoot proliferation. The headland effects of AC on morphogenesis may be mainly due to its permanent adsorption of inhibitory compound in the culture medium and considerably decreasing the toxic metabolites, phenolic exudation and brown exudates accumulation. The effect of AC on growth regulator uptake is still unclear but some workers believe that AC may gradually release certain adsorbed products, such as nutrients and growth regulators which become available to plants. This review
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focuses on the various roles of activated charcoal in plant tissue culture and the recent developments in this area. (Thomson, 1982)

Infect that, there is no real wax oil industry in Egypt and this due to inadequate plant material far rising in the desert and other place in Egypt. Jojoba is clonally propagated by nodes and the rate of propagation is very incomplete because the nodes are hard to ancestry, so that the only solution to solve this problem is through the rapid mass production by tissue culture technique. Jojoba is a hot and subtropical plant; the major row material is wax esters (Jojoba oil) manufacture and has a big market in the entire world.

In this report we describe the purification of a membrane – connected, NADPH- dependent alcohol- forming far from mounting jojoba embryos, as well as the clone of a C-DNA that encodes FAR. The identity of the C-DNA clone was established by detection of FAR activity and free alcohols in bacteria expressing the clone. In addition, we show that expression of the jojoba C DNA in developing embryos of Brassica napus results in not only the mixture of long chain alcohols in the transformed tissues, but also in the appearance of novel wax esters. Conversion of the fatty alcohols to waxes in the transgenic plants is not always total, and the overall tallness of alcohols and wax manufacture is relatively low.

The plants have remarkably deep tap root system that help to survive in drought conditions. Hence, it can be successfully grown in arid and semi-arid areas of Pakistan. Its usual life span appears to be between 100 and 200 years. The product, which is trade, is called jojoba oil potential world production of this manufactured goods is currently around 3,500 metric tons per year. The cosmetic industry appears to be the principal market for jojoba oil products around 3,500 metric tons per year are consideration to be utilized by this industry, this equates to almost 80% of the total market share. The other major industry by means of jojoba oil is the pharmaceutical sector. Lubricant applications supply a market for around 100 tons of jojoba oil annually. Jojoba oil is a high quality substitute for sperm oil (from the sperm whale); availability of this product is limited now due to the restrictions placed on whaling. Plantations are established by using seeds, seedlings,
rooted cuttings, or plantlets produced from tissue culture (Roussos et al.; 1999) Plant vigor, more figure of shoot and leaves are important features for good survival and growth of the plant. The growth of aerial plant parts exclusively depends upon the subterranean plant parts. So for normal growth and development of aerial plant parts proper and suitable environment must be provided to the root system (Weiss, 1983).

Thomson, 1982, used vermiculite as a medium for jojoba cuttings. Feldman et al., 1982, reported that incorporating osmocate into the potting media consisting of mixture of perlite and vermiculite (1:1) had an advantage for jojoba cuttings. Correlations between tissue nutrient levels showed significant relationships between % nitrogen in shoot and node number per cutting shoot potassium levels were highly significantly connected with node highly considerably correlated with swelling number per cutting. Lee and Palzkill, 1984, found that jojoba cuttings rooted significantly more in mixture of perlite and vermiculite as potting medium for jojoba cuttings is also reported by National Research Council of USA (1985). Feldman et al; 1982, successfully rooted jojoba cuttings in perlite; vermiculite (1:1) medium under mist with bottom heat. Harsh and Muthana, 1985, used coarse river sand, sandy soil, or a mixture of the two for stem cuttings of jojoba. Palzkill, 1988, subsequent to trying many different media settled on a mixture of perlite and vermiculite (1:1) for sticking the jojoba cuttings in flats and a mixture of peat, perlite and vermiculite (1:1:1) for sticking the cuttings in individual containers.

Palzkill and Feldman, 1993, compared three rooting media perlite: vermiculite (1:1); peat: perlite (1:1) by volume for jojoba cuttings. The peat – perlite (1:1) by volume for jojoba cuttings. The peat – perlite medium resulted in significantly less rooting than did the other two media. However, rooting occurred 74% for perlite-vermiculite, 78% for peat –perlite – vermiculite and 64% for peat – perlite medium resulted in significantly less rooting than did the other two media. Propagation medium is composed of an organic component (peat, Sorghum mass sawdust or hardwood and softwood barks) and a coarse mineral component. Organic matter has a thoughtful effect on biological, chemical and physical properties of the medium. Through the decompositions of organic matter, chemical elements became available to the matter; chemical elements became available to the crop plants.
Organic matter provides food and energy for soil structure. The coarse mineral component (crude sand or grit etc.) is used to increase the proportion of large air-filled pores and drainage. Rarely internal soil is used as a propagation medium component, except in field propagation of hardwood cuttings. Most propagators use a combination of organic and mineral component i.e.; peat – bark- sand, peat – Rockwool etc. Prat et al., 1998, studied the rooting of semi-hardwood cuttings of 5 jojoba clones in 5 substrates and noted significant differences in rooting among clones but no effect of substrate. Bashir et al., 2001, raised IBA treated jojoba cuttings in sand and silt media. Study were conducted to see the effect of various potting media in different combinations of potting media presented more growth and vigor of the place along with improving total obtainable nitrogen and phosphorus. Weiss, 1983, studied the effect of different soil media on the growth of Draceana dermensis var. Janet craige cuttings.

Direct cuttings of Dracaena were planted in 15cm clay pots containing different soil mixture such as silt saw dust, leaf mold and garden soil. They found that soil media of silt garden soil + leaf mold garden soil gave maximum stem length.

Jojoba is a sluggish growing plant. In the hardening process of rooted cuttings the cuttings should be shifted to such a soil medium that may augment its growth and vigor before going to the field plantations. The current study has been conducted with this idea and the efforts have been focused on the choice of the best medium from the available cheap resources of organic matter and on the response of selected clones to these soil media in terms of growth and survival.

Jojoba is a new manufacturing raw material. It is unique wild plant species, widely distribution in semi-arid regions of Arizona, California and Baja California (USA) over an area of 2.6\times10^8 Km^2 between latitudes 25 and 31 °N (Benzioni, 1997; Yermanos, 1979). Jojoba seed contain 40 to 50% oil, which is used in cosmetics e.g. lotions, moisturizers, massage oil, smoothing cream, shampoos gels, lipsticks and nail polishes. There are many latent uses of jojoba oil in pharmaceutical plastic, printing and lubricant industries (Benzioni, 1997).
The germination and growth of jojoba is forbidden by various agro-climatic factors eg. temperature, soil -type, salinity level of the soil, water and methods of sowing. In the past some scientists conducted the research on these aspects. Thomson, 1982, recorded that mature seeds germinated readily in alkaline sandy media when daily temperature ranged from 80 to 100°F and seeds did not germinated but died at 100 to 110°F. While anonymous, 1985, reported the best jojoba planting in late spring or early fall when soil hotness was between 21 to 35 °C. The good germination 75 to 78% occurred when temperature exceeds from 21 to 35°C as stated by (Kuepper, 1981).

Growth behavior of jojoba on a variety of types of soil was studied by Anonymous, 1985, stated that jojoba is restricted to well drained coarse and desert soils. Thomson, 1982, recorded that jojoba is very flexible in its soil requirements, having properties of well drained, coarse, light or medium textured and complete water penetration. Kuepper, 1981, and Stone, 1986, concluded that jojoba grown in heavier soils exhibit slow growth and develop root problem, so this is unsuitable. Benzioni, 1997, and Baxter, 1998, investigated that best soil profile for jojoba therefore has good interior drainage.

The jojoba family (Simmondsiaceae), has only one genus, Simmondsia, consisting only one species, Jojoba. Earlier, jojoba was considered as an isolated member of the Box family (Buxaceae), but now it is regarded as adequately distinct to be placed in a separate family. Jojoba is found in coastal and cis-mountain Southern California east to central Arizona and south to Sonora and Baja California (Yermanos, 1974).

The jojoba, native to the arid zones of the United States and northern Mexico, produces a seed that contains a liquid wax (jojoba oil) useful in cosmetics, pharmaceutical products and industrial lubricants (Yermanos, 1974).

The presence of a family of cyanoglucosides, the Simmondsins, which are highly toxic to rats, mice, chickens, rabbits, and sheep, has prevented direct utilization of the meal (Booth et al., 1974; Weber and Reid, 1975).
We report the elimination of toxic and bitter components of jojoba flour and meal with aqueous isopropanol. The physical – chemical characterization and biological evaluation of the detoxified and debittered products are presented.

Although some components of native jojoba seed meal Simmondsin, has ferulate analogs that absorb UV radiation, jojoba oil has no UV absorbing species by incorporation of several molecules of trans-4 –hydroxy- 3 – methoxycinnamic acid (ferulic acid) into the structure of the tetrahydroxyjojoba wax (THJF) or to the diepoxi jojoba wax (EPX).

The other three species sampled the beans and then refused to eat until starvation occurred. Due to these and other studies growers felt rodents and other pest animals held little threat to the crop.

Poor jojoba crop prices and other economic factors led to elimination of harvest and eventually to termination of irrigation and other cultural practices on most planting in the mid -1980’s. This lack of proper management contributed to the build-up of rodents in the plantations, when prices for jojoba seed products rebounded in 1988, growers prepared to harvest jojoba fields that had not been totally abandoned. Plants were skirt pruned, watered and the ground was smoothed for the anticipated harvest. According to crop production managers for the plantings subject to this study, a good crop of beans (seeds) were on the plants and harvest neared in July, the crop suddenly began to suspect that the crop had been harvested by the wrong crews.

Phenolic compounds, a trypsin inhibitor and phytic acid are the compounds proposed as the plants toxic constituents (Storey et al., 1983; Wiseman, 1983). Wiseman 1983 reported 8% polyphenolic content in defatted jojoba meal. It was observed that the presence of glucosides in the plant. Cokelaere et al., 1995 and Abbott et al., 1999, isolated simmondsin from jojoba meal. Jojoba oil yielded unsaturated, long-chain alcohols on sodium reduction (Molaison et al., 1957). The main components in jojoba wax are the wax esters, eicosenyl docosenoate, eicoseryl eicosenoate, docosenyl eicosenoate, eicosenyldocosenoate and tetracosenyl
eicosenoate (Tada et al., 2005). Jojoba defatted meal contains toxic compounds mainly simmondsin and simmondsin-\(^{-}\)ferulate (Suzanne et al., 2011; Elliger et al., 1973; Verbiscar and Banigan 1978). Seven simmondsin derivatives have been identified and quantified, these include: simmondsins, \(-5\)-demethylsimmondsins, 4-demethylsimmondsins, simmondsin 2'-trans-ferulates, \(-5\)-demethylsimmondsins 2'-trans-ferulates, 4-demethylsimmondsins 2'trans-ferulates and didemethylsimmondsins (Kolodziejczyk et al., 2000; Benzioni et al., 2005).

The complete absence of glycerin in the seed oil makes it a liquid wax, not fat (Abu Arabi et al. 2000). The seeds without testa have been reported to contain 1.1% phenolics, whereas for tests the value 6.5% has been reported (Medina and Trejo-Gonzalez, 1990), whereas. It was found that defatted jojoba meal contained 2.67% phenolic compounds. The presence of tannins and phenolics was also reported in the seeds of the plant (Goyal et al., 2003; Maxson and Rooney, 1972). Several authors have isolated the anti-nutritional compound, simmondsin, from the residual cakes and jojoba seeds (Elliger, et al., 1973; Flo et al., 1997; Kolodziejczyk et al., 2000; Brown, 1985). Goyal et al., 2007, reported the presence of p-anisidine in the seeds. Goyal et al., 2007, showed the presence of conjugated dienes and trienes in the seeds. Perez-Gil et al., 1989, observed the presence of cyanogenic glucosides, methioninem lysine and isoleucine in the seeds. In jojoba meal 1-oleoyl-3-lysocephatidylcholine and 1,2-dioleoyl-3-phosphatidylcholine (12), pinnitol \(\alpha\)-D-galactosides 5-O-(\(\alpha\)-D-galactopyranosyl)-3-O-methyl-D-chiro-inositol or 5-\(\alpha\)-D-galactopyranosyl-D-pinitol and 2-O-(\(\alpha\)-D-galactopyranosyl) )-3-O-methyl-D-chiro-inositol or 2-alpha-D-galactopanosyl-D-pinitol (Van Boven et al., 1991), and simmondsin [2-(cyanomethylene)-3 hydroxy 4,5 dimethoxy cyclohexyl beta-D-glucoside] and simmondsin ferulates (Van Boven et al., 1991; Flo et al., 1997) were identified. Simmondsin, \(4\)-demethylsimmondsin, \(5\)-demethylsimmondsin and \(4,5\)-didemethylsimmondsin were isolated from jojoba seed meal (Lein et al., 2002). In jojoba meal, the major proteins are albumins and globulins (Sherestha et al., 2002). Jojoba seed is a source of xyloglukan oligosaccharides (Hantus et al., 1997). The plants seed contains high tannin concentration (Goyal et al., 2007). Defatted jojoba
meal contains 50% pentosans (Abbott and Holster, 1999; Kolodziejczyk et al., 2000).

Sharma et al., 2011, extracted the roots of the plant with various solvent to study the chemical constituency. Petroleum ether extract showed the presence of steroids and fixed oils, whereas chloroform extract showed proteins and amino acids, flavonoids and steroids. Ethanol and water extract showed the presence of proteins and amino acids, carbohydrates, tannins and phenolics and flavonoids.

Leaves contain biologically active flavonoids, neutral glycol- and phospholipids.

It was observed that significant antimicrobial activity of hexane and ethanol extracts of pericarp of the plant on yeasts and moulds. Suzanne et al., 2011, investigated the antibacterial activity of various extracts of the seed cake of the plant against *Staphylococcus aureus*, *Salmonella typhimurium*, *Listeria monocytogenes*, *E.coli* and *Bacillus cereus*. A weak antibacterial activity was observed against the tested organisms. The acetone extract inhibited only *Salmonella typhimurium* and *Listeria monocytogenes*.

Toxicity studies involving both purified simmondsin and defatted jojoba meal have shown that toxicity is species specific (Booth et al., 1974). Dimayuga et al., 1998, studied the antimicrobial activity of the ethanol extract of the plant against *Staphylococcus aureus*, *Bacillus subtilis*, *Streptococcus faecalis*, *E.coli*, *Candida albicans* and was found active against none.

It was, studied that the antifungal activity of glycosides isolated from the seeds of the plant. The antimicrobial activity of the liquid wax has been reported by many authors (Habashy et al., 2005; Prijck et al., 2008).

*Simmondsia chinensis* (Link) Schn. (jojoba) is a nontraditional crop in arid and semi-arid areas. It is naturally well adapted to saline soils and high temperature environmental conditions (NAS, US, 2002). Jojoba seeds store lipids in the form of liquid wax that makes up 40–60% of their dry weight. This wax and its derivatives
have potential for wider applications in cosmetics, pharmaceuticals, lubricants, extenders, and antifoaming agents (Mills et al., 1997; Benzioni et al., 1999). There is an increased interest in the agricultural production of jojoba and more promising experience has accumulated every year respecting cultivation requirements, planting densities, management practices, productivity, propagation techniques, and genetic improvement (Mills et al., 1997).

Jojoba is dioecious and unable to initiate sexual reproduction before flowering (usually 2–4 years from germination). Propagation by direct seeding has genetic heterogeneity and half of the seedlings are males. However, 8–10% males are necessary for pollination (Reddy and Chikara, 2010). Setting up a plantation with asexual propagules is more expensive than with seed, and saves time in transplanting plants as well as crop produced of known sex and lineage. Vegetative propagation can be achieved by layering, grafting, or rooting semi hardwood cuttings, but the highest number of propagules is limited by plant size and time of year (Mills et al., 1997; Reddy and Chikara, 2010). Micro propagation of elite individuals exploits totipotency of plant cells and offers a promising means of commercial mass production of pathogen-free superior clones. In vitro- derived jojoba plants grow more vigorously than both seedlings and rooted cuttings, and are significantly larger after the first year of growth (Chaturvedi and Sharma, 1989; Reddy and Chikara, 2010). Some protocols for in vitro culture of jojoba are known. There are reports of jojoba somatic embryogenesis from zygotic embryo (Gaber et al., 2007; Aly et al., 2008) and leaf explants (Aly et al., 2008; Hamamma et al., 2001). A number of researchers have described in vitro culture of single-node explants using both axillary and apical buds (Llorente and Apostolo, 1998; Prakash et al., 2003; Tyagi and Prakash 2004; Llorente et al., 2007; Bashir et al., 2008; Singh et al., 2008; Mohassemb et al., 2009). Shoots exhibited differential morphogenic behavior under the influence of growth regulators and adjuvants during in vitro propagation (Llorente and Apostolo, 1998; Prakash et al., 2003; Tyagi and Prakash 2004). Variations in the response of the explants have been observed in terms of percentage of shoot regeneration, proliferation rate, shoot length, callus presence, and rooting behavior Llorente and Apostolo, 1998; Prakash et al., 2003; Tyagi and Prakash 2004).
Some genotypes exhibited 75% root formation while others displayed scarce rooting in medium with 6 μM indole-3-butyric acid (IBA) (Llorente and Apostolo, 1998) and the pulse treatment of 50 μM IBA caused 44–67% in vitro rhizogenesis of various genotypes tested (Tyagi and Prakash, 2004). On the other hand, no significant difference in bud initiation, rooting and survival in greenhouse was observed in some genotypes studied (Singh et al., 2008).

Micro propagation is highly recommended strategy for obtaining jojoba elite clones. For culture initiation, single-node explants are cultivated on Murashige and Skoog medium (MS) supplemented with Gamborg’s vitamins (B5), 11.1 μM BA (N 6-benzyl-adenine), 0.5 μM IBA (indole-3-butyric acid), and 1.4 μM GA₃ (gibberellic acid). Internodal and apical cuttings proliferate on MS medium containing B5 vitamins and 4.4 μM BA. Rooting is achieved on MS medium (half strength mineral salt) amended with B5 vitamins and 14.7 μM IBA during 7 days and transferred to develop in auxin-free rooting medium. Plantlets are acclimatized using a graduated humidity regime on soil: peat: perlite (5:1:1) substrate. This micropagation protocol produces large numbers of uniform plants from selected genotypes of jojoba.